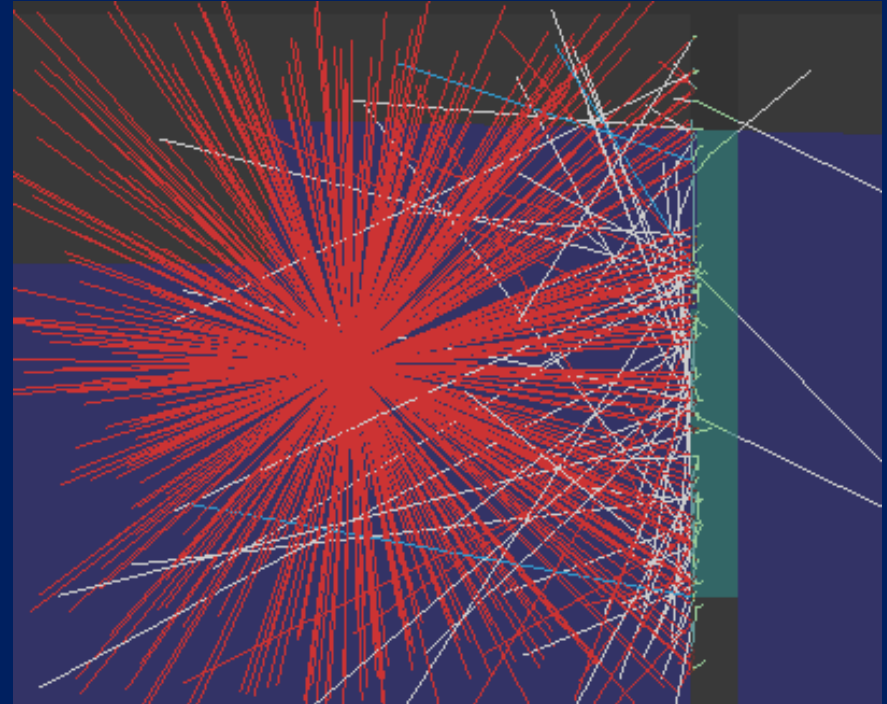


Virtual Cloud Chamber

Particle Interaction with Matter - Simulation

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Cloud Chamber

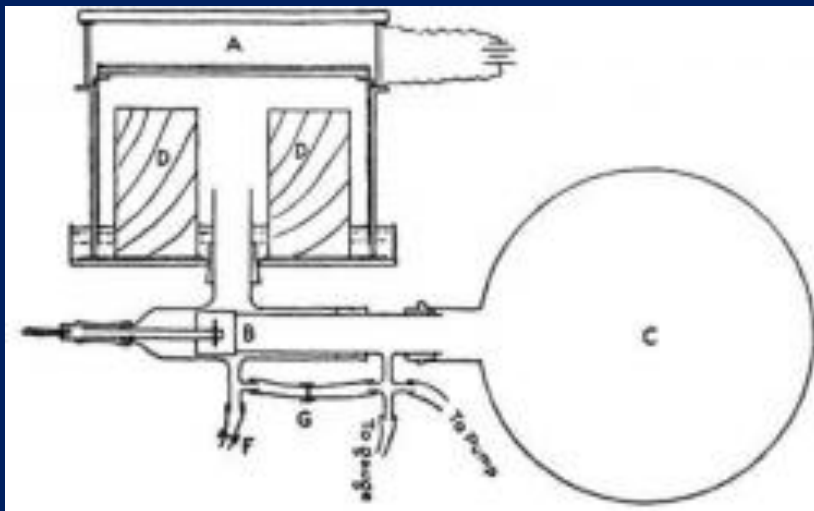
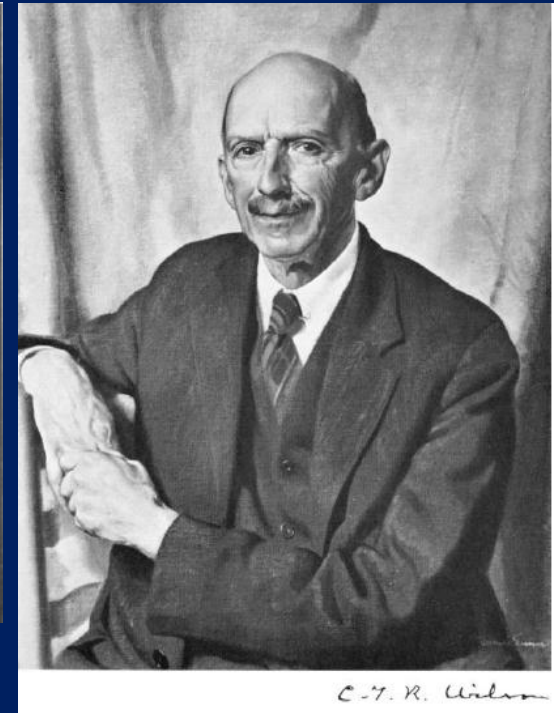
The cloud chamber was invented by the Scottish physicist CTR Wilson around one hundred years ago (1911 and 1912).

“the most original and wonderful instrument in scientific history” (Rutherford)

“The invention ... first revealed to the eyes of mankind the intimate details of the behaviour of the elementary particles of nature.”
(Blackett)



tracks of alpha particles
from a radium source



A rapid expansion of chamber A causes water droplets to condense on ions in the air. Radiation creates a trail of ions in the chamber. These become a track of water droplets which show up when viewed under strong illumination. The photographs show tracks of alpha particles emitted by a radium source.

Wilson's cloud chamber. A — the cloud chamber,
B — a piston, C — a vacuum chamber

Virtual Cloud Chamber:

The Virtual Cloud Chamber is an online interactive simulation tool for investigating the motion of charged particles and photons in different media. The simulation tool, which is based on the Mont Carlo GEANT 4 Engine, has been developed and integrated into the NUCLEONICA nuclear science and data portal.

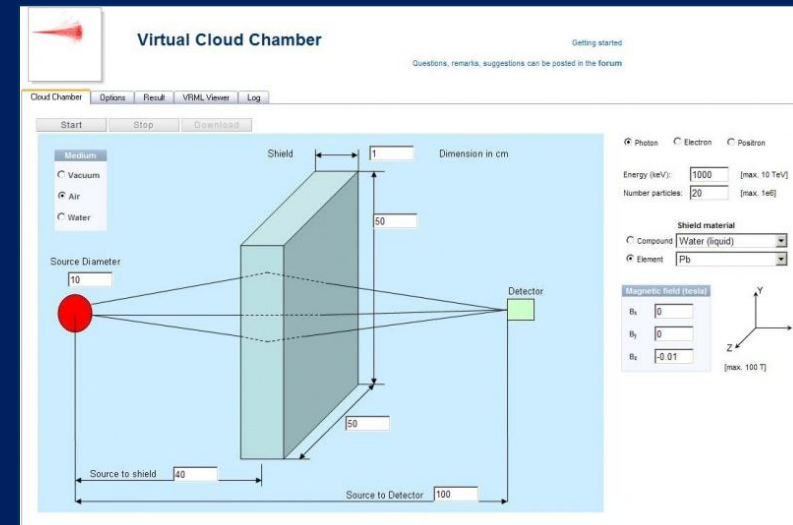
For the investigations, sources of mono-energetic particles are used. Initially the simulations are restricted to photons, electrons and positrons. To better understand the charged particles emission processes, the various energy loss mechanisms can be "switched-off" in the calculations - otherwise the range of the charged particles would be very small and almost invisible.

For photons, there the various energy loss processes - photoelectric effect, Compton scattering, and pair production - can also be switched on/off. In the images, the colour scheme - based on the colours used in the Karlsruhe Nuclide Chart - is as follows: white (photons), blue (electrons) and red (positrons). The calculations are based on the Monte Carlo GEANT 4 Engine.

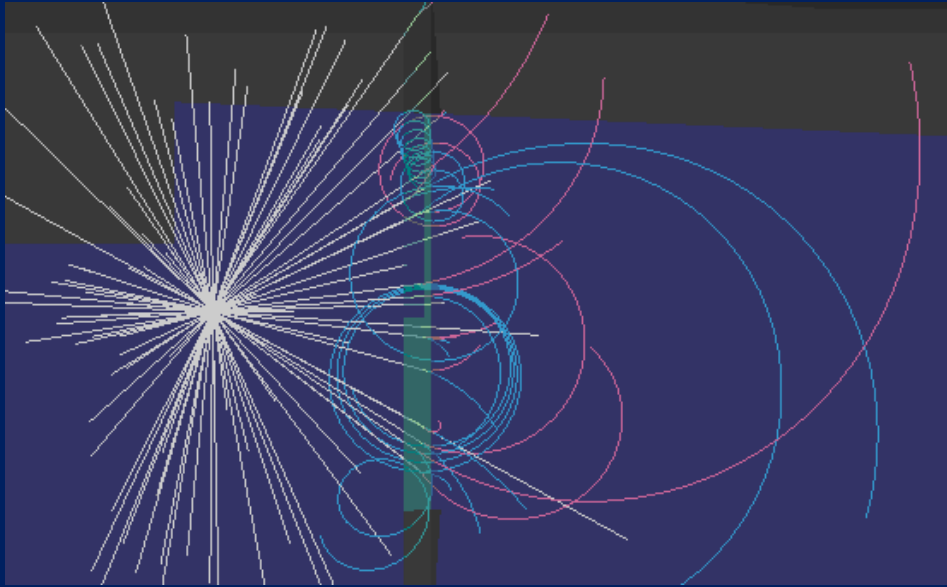
What is Geant4?

Geant4 is the successor of GEANT3, the world-standard toolkit for HEP detector simulation.

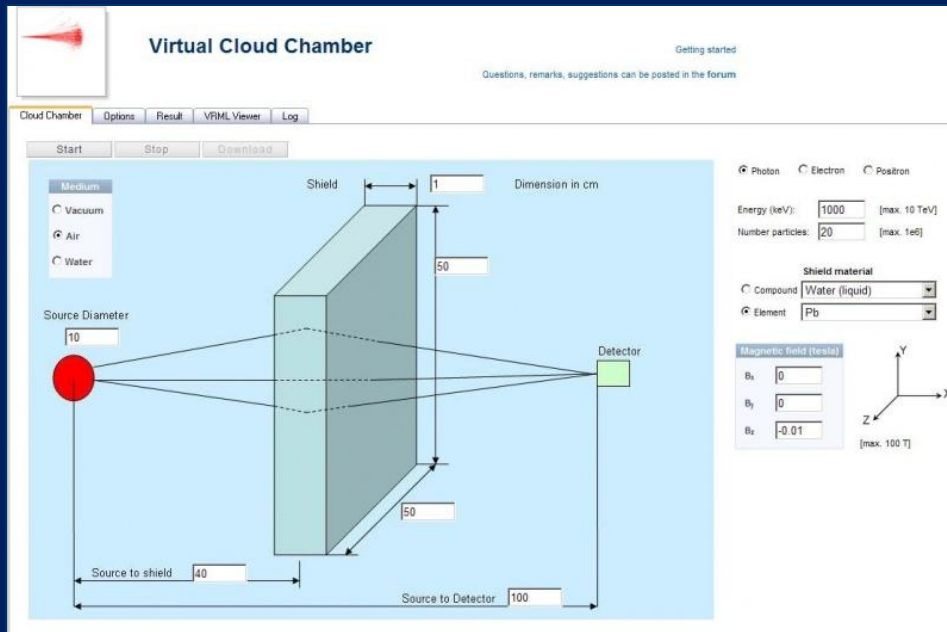
Geant4 is one of the first successful attempt to re-design a major package of HEP software for the next generation of experiments using an Object-Oriented environment.



Example 1: Virtual Cloud Chamber



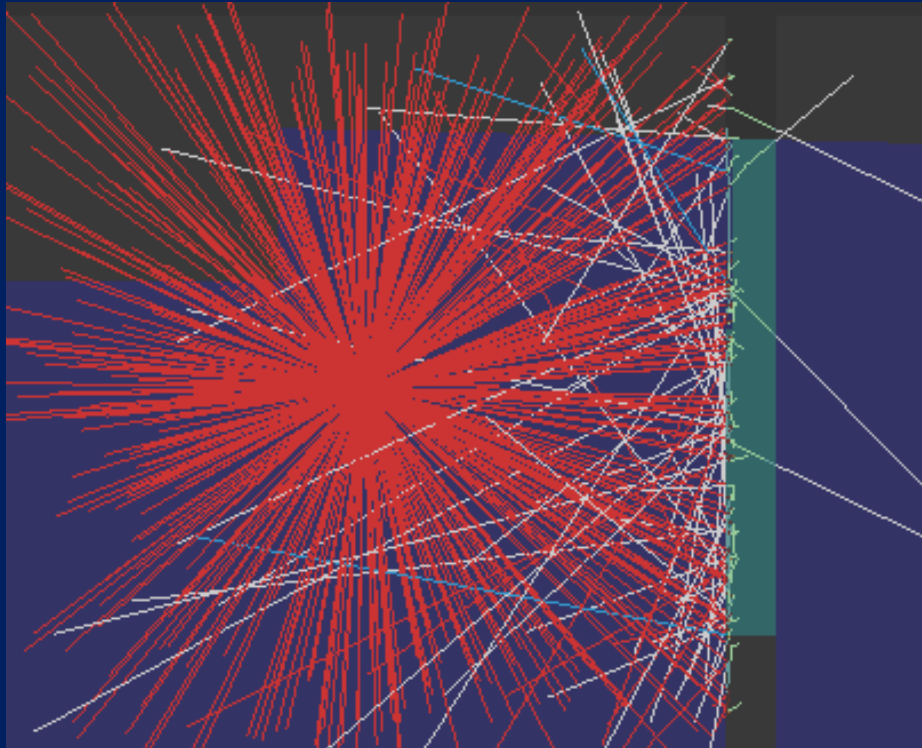
In this example, electron-positron pairs are created through the interaction of 10 MeV gamma photons incident on lead. By “switching off” the electron and positron energy loss mechanisms, the charged particles are seen to spiral in the applied magnetic field. Information on the energies of the electrons and positrons can be obtained from the diameter of the trajectory in the magnetic field.



Parameters used in the simulation (in addition to default values):

- Medium = Vacuum, Source diameter = 0 (point source)
- Source to shield distance = 20 cm
- Type of particle = photon, Energy of particle = 10 MeV
- Number of particles = 100, Magnetic field = $B_z = -0.1$ tesla
- Electron and positron interaction mechanisms (ionization, Bremsstrahlung, scattering, annihilation) all "switched off"

Example 2: Shielding of High Energy Radiation



In this example, 3 MeV positrons (red) from the radioactive source are blocked by a lead shield (green). When the positrons collide with the shield, they combine with electrons (blue) to create gamma radiation (white). Only a few gamma photons pass through the shield material. In this simulation the following parameters were used:

Parameters used in the simulation (in addition to default values):

Medium = Vacuum

Source diameter = 0 (point source)

Type of particle = positrons

Energy of particles = 3000 keV

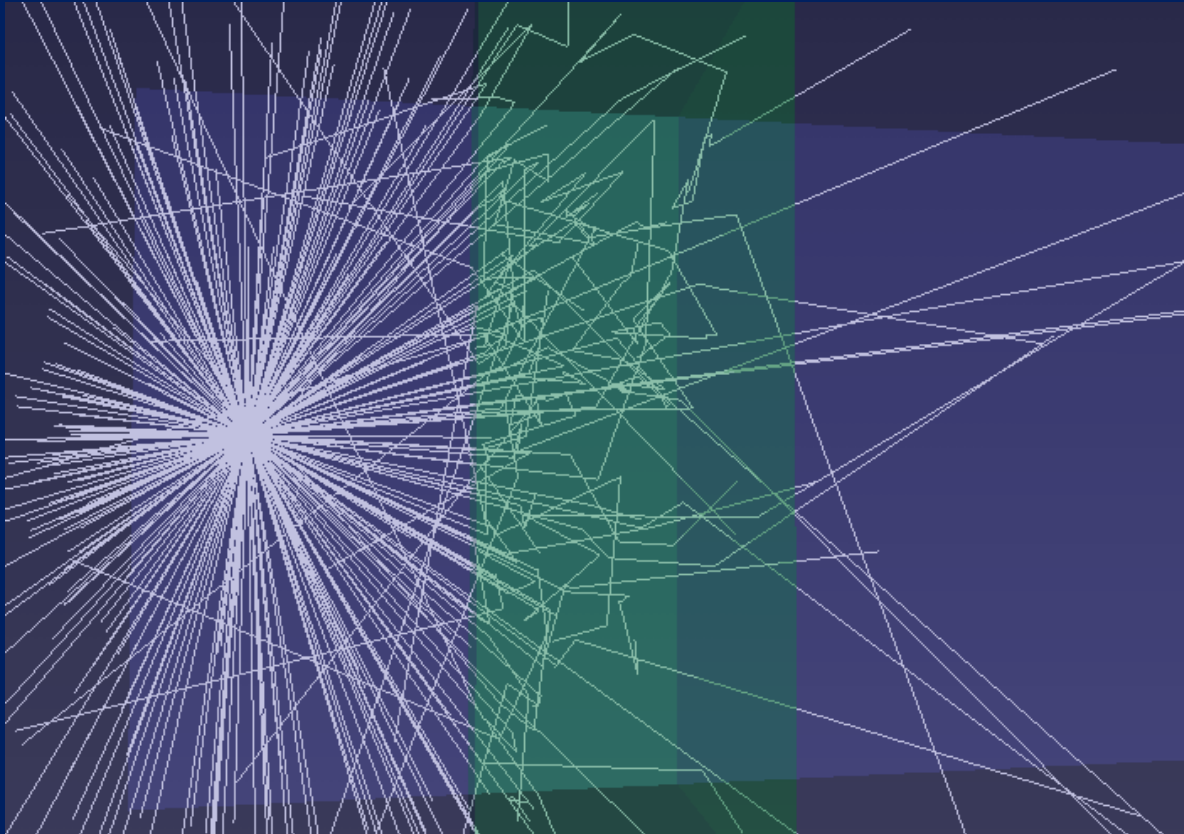
Number of particles = 1000

Source shield distance = 20 cm

Shield thickness = 3 cm

All photon, electron and positron interaction mechanisms "switched on"

Example 3: Photon Multiple Scattering



In this example, low energy photons (energy 100 keV) are attenuated with a thick (15 cm) water shield. This combination of low energies and thick shields give rise to multiple scattering of the radiation.

Parameters used in the simulation (in addition to default values):

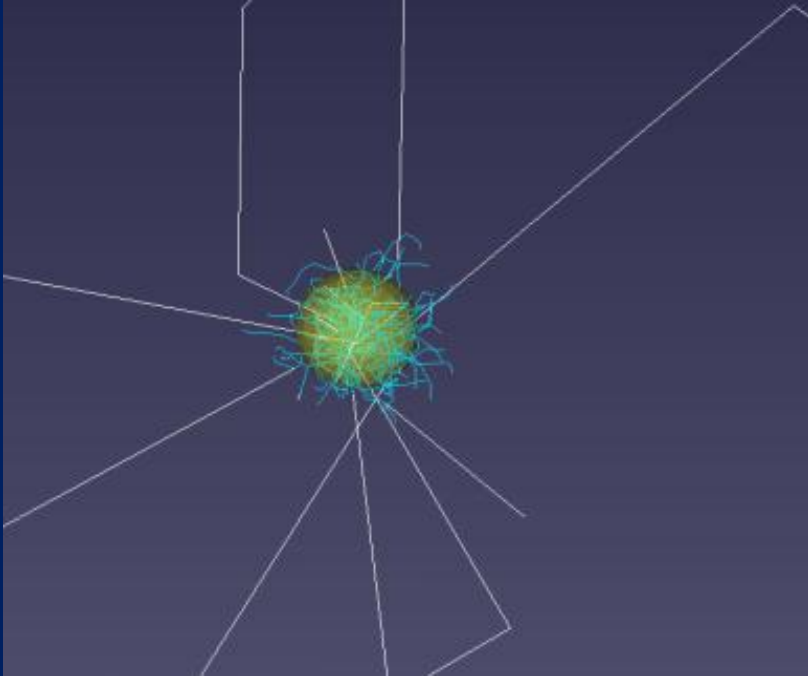
Medium = Vacuum, Source diameter = 0 (point source)

Source to shield distance = 20 cm

Type of particle = photon, Energy of particle = 100 keV

Number of particles = 300, Magnetic field = $B_z = 0$ tesla

Example 4: Selective Internal Radio-Therapy (SIRT)



For the simulation electrons are selected and the energy is set to 2.28 MeV (2280 keV). The simulation media selected is water (since that is very similar to tissue). The source diameter is set to 1 cm - this highlights a volume of tissue corresponding to the range of the beta particles.

Just released...

Cloud Chamber Animation –
check it out!

Thanks!